Technically Advanced Aircraft Flying Handbook

Extended Table of Contents and Chapter Excerpts

Purpose

This document contains an **extended table of contents** and two **chapter excerpts** for a future technical publication about the technically advanced cockpit. The challenges of learning, teaching, and testing in technically advanced aircraft emphasize the need for a “go-to” guide that will be of practical use to students, pilots, instructors, and pilot examiners.

Extended Table of Contents
The extended table of contents briefly enumerates a collection of knowledge and skills that contribute to the safe and proficient use of technically advanced cockpit systems. The knowledge and skills presented in the table of contents fall into two general categories:

> **Technical knowledge and skills** focus on procedural and conceptual mastery of the equipment. The technical knowledge and skills describe many of the details that are important for the safe and proficient use of advanced avionics. Interpreting an approach plate to determine the correct missed approach point and decision altitude when GPS augmentation services are used is an example of technical knowledge and skill. Responding to a loss or degradation of signal during a WAAS approach is another example.
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> **Human factors knowledge and skills** focus on the changed role of the pilot in a technically advanced cockpit. These knowledge and skills attempt to more concretely define broad-brush notions such as situational awareness, aeronautical decision-making, risk management, and single-pilot resource management. The knowledge and skills presented in this document attempt to turn abstract human factors notions into teachable and testable line items. The first section of the extended table of contents is dedicated to general human factors topics that apply across many aspects of flying in technically advanced aircraft. How the use of automated systems can sometimes decrease and sometimes ironically increase pilot workload is an example of general human factors knowledge.
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> A collection of more specific human factors knowledge and skills are distributed throughout the document, pointing out competencies particular to equipment, functions offered by equipment, instrument procedures, or phases of flight. The importance of verbal callouts to maintain altitude awareness when an autopilot and altitude alerter is used is an example of a situational awareness “line item.” Loss of altitude awareness when autopilots are used is a well-known operational problem, while altitude callouts, designed to remedy the problem, are standard operating procedure at most airlines.

The knowledge and skills presented here are limited to operating the avionics equipment found in technically advanced aircraft. More general topics, such as go/no-go decision making, aircraft performance, or aircraft parachute systems are not covered here.

Chapter Excerpts
The two sample chapter excerpts illustrate how a future technical publication will expand the brief entries that appear in the extended table of contents into more complete, textbook-like descriptions.

Call For Participation

The extended table of contents and chapter excerpts are works in progress and are being developed through industry-wide collaboration. We are conducting many focus-group sessions with different populations of pilots, flight instructors, pilot examiners, engineers, researchers, policymakers, and others who work with technically advanced aircraft. These industry pioneers make up our nation's collective expertise, and only they can ensure the document's quality and completeness.

In short, we need you not only to share your technical and human factors knowledge, but also to help us understand what kind of future technical publication will prove to be most useful to aviators in their everyday practice.

The extended table of contents and chapter excerpts currently use an organization similar to that used by the FAA-H-8083-15 (*Instrument Flying Handbook*), but many others will be considered and we again welcome your inputs.

All inputs are welcomed and should be sent to: Stephen.Casner@nasa.gov

1. Human Factors

A. MODES AND MODE MANAGEMENT

1. Mode management concepts

The concept of a moded system: one that produces different behaviors depending on which modes are currently in use. The challenge of maintaining awareness of which modes are in use. Understanding the present and future behavior of a moded system. Mode management as a new piloting skill – one that takes practice. Opportunities for becoming confused in flight, and its consequences.

B. LEARNING AND UNDERSTANDING

1. Importance of understanding

Why learning knobs-and-dials procedures is not enough. Learning more about how advanced avionics systems work leads to better memory for procedures, and allows pilots to solve problems they haven't seen before.

2. Limits of understanding

How it is generally impossible to understand all of the behaviors of a complex avionics system. Knowing to expect surprises, and to continually learn new things.

C. AWARENESS

1. Human vigilance

Humans are characteristically poor monitors of automated systems. When asked to passively monitor an automated system for faults, abnormalities, or other infrequent events, humans perform poorly. The more reliable the system, the poorer the human performance.

2. Primary/secondary task inversion

A pitfall of automation in which the pilot only monitors a backup alert system, rather than the situation that the alert system is designed to safeguard.

3. The paradox of automation

How technically advanced avionics can both increase and decrease pilot awareness.

4. Techniques to enhance awareness

Practices that help ensure that awareness is enhanced by the use of automation, not diminished (e.g., procedures such as callouts).

D. ERROR

1. Human capacity for error

How error is a key attribute of human behavior. Human error rates for everyday tasks. The challenge of detecting your own errors and errors made by others.

2. Kinds of errors

Mistakes as errors in planning: overgeneralization, forgetting, misconception. Slips, lapses as errors of execution: capture errors, double-capture errors, omissions due to interruptions, perceptual confusions, action spoonerisms, and overattention.

3. Techniques for reducing human error

Routine procedures, checklists, forcing functions, redundancy, use of other crew members. The concept of error-tolerant procedures.

4. Automation and errors

Automated systems can make some errors more evident, and sometimes hide other errors or make them less evident.

E. RESOURCE MANAGEMENT

1. Resource management concepts

The flight environment as a system of people, equipment, and other resources. Importance of understanding what each resource offers. Matching resources to tasks. Delegation of tasks to and management of resources. Leadership and followership roles. Teamwork and communication. Conflict resolution.

2. Choosing cockpit automation resources

Advanced avionics offer multiple levels of automation, from strictly manual flight to highly-automated flight. No one level of automation is appropriate for all flight situations. The importance of choosing the right level of automation for any situation.

3. Managing workload

Using automation (e.g., autopilot) to reduce workload. How automation can sometimes inadvertently raise workload.

4. Distractions
Greater opportunity for distraction in technically advanced aircraft.

F. SKILL ATROPHY

1. Skill atrophy
Skills that are not practiced deteriorate. This principle applies to manual flying skills as well as advanced avionics skills.

G. RISK TAKING

1. Humans and risk
The effect of known and unknown risk on human decision-making. How humans routinely misestimate risk. Risk homeostasis.

2. Automation and risk taking
Automated systems that provide more information about a risky situation can sometimes prompt pilots to accept more risk.

3. Risk assessment techniques
Practical techniques for recognizing and assessing risk in everyday flight situations (e.g., PAVE).

H. DECISION MAKING

1. General factors affecting human decision making
How knowledge, experience, attitude, personality, emotion, physiology, fatigue, and other factors affect decision making.

2. Human reasoning under certain and uncertain conditions
The problem of making decisions under varying degrees of certainty. The effects of certainty or additional information on decision making.

3. Common decision making pitfalls
Framing effects, representativeness, the gambler's fallacy, availability, confirmation bias, correlation errors, causal reasoning biases, hindsight bias, anchoring bias, etc.

4. Decision making techniques
Practical techniques for making decisions and their likely effectiveness (e.g., the D-E-C-I-D-E model).

2. Flight Instruments

A. PRIMARY FLIGHT DISPLAYS

1. Flight instrument interpretation
Interpreting the attitude, heading, airspeed, vertical speed, rate of turn, slip/skid, and trend indicators.

2. Cursors and bugs
Purposes and setting of instrument cursors and bugs.

3. Flight instrument systems
How primary flight instruments work. Information sources for each instrument. Interconnections between instrument systems. Instrument system failure behaviors.

4. Digital vs. analog displays
Differences between digital and analog displays (e.g., conventional altimeter vs. altitude tape).

5. Instrument system cross-check
Cross-checking the primary (digital) and secondary or backup (analog) instruments.

6. Limitations of the primary flight display
Limitations stated in the pilot operating handbook (POH) or airplane flight manual (AFM).

7. PFD failure
Indications for a failure of the primary flight display. Pilot actions required to continue flight.

B. ELECTRONIC NAVIGATION INDICATORS

1. Navigation sources and displays
How multiple sources of navigation information can be presented on multiple navigation displays. How to display all possible navigation sources on each navigation display. The importance of remaining aware of which navigation sources are displayed on which instruments. Potential for confusion.

2. Certified vs. non-certified instruments
Which displays and instruments are approved for IFR navigation.

3. Common Error: Mis-set navigation source and/or indicator.

4. Failure indications
Recognizing failure indications for all area and radio navigation equipment. Pilot actions required to continue flight in case of failure(s).

C. ELECTRONIC FLIGHT INSTRUMENT PREFLIGHT PROCEDURES
1. AHRS/IRU Alignment
Alignment procedures for attitude/heading reference systems or inertial reference systems.

3. Navigation Systems

I. AREA NAVIGATION

A. AREA NAVIGATION BASICS

1. Area navigation concepts

The basics of to-to navigation, the waypoint, and a leg as a great circle track defined between two waypoints. Required navigational performance (RNP).

2. Area navigation computers

Types of area navigation computers (e.g., GPS, GPS/WAAS, FMS, RNP 0.3). Functions performed by an RNAV-capable navigation computer.

3. RNAV signal status

Area navigation computer indications of RNAV signal status. Responding to signal status problems (i.e., loss of signal integrity, availability, accuracy, or continuity).

B. FLIGHT PLANNING

1. IFR-certified RNAV computers

Regulatory requirements for RNAV computers that are used for IFR flight.

2. Alternative means of navigation

Regulatory requirements for alternate navigation systems, and when they must be actively monitored.

3. RNAV limitations

Operating limitations of the RNAV computer as described in the pilot operating handbook (POH) or aircraft flight manual (AFM) supplement.

4. NOTAMs relevant to GPS

NOTAMs applicable to using GPS and WAAS under IFR.

5. RAIM predictions

Predicting RAIM to destination (non-WAAS receivers).

6. Navigation database

Contents of the electronic navigation database. Requirement for all instrument procedures to be selected from the electronic navigation database.

7. Navigation database currency
Determining whether or not a navigation database is current.

8. En route waypoints
Entering en route waypoints into the flight plan.

9. User-defined waypoints
Creating user-defined waypoints. Inserting user-defined waypoint into the flight plan.

10. Installing instrument procedures
Loading departure, arrival, and approach procedures and transitions into the flight plan.

11. Reviewing the route
How to verify that the programmed flight plan agrees with the IFR clearance using the RNAV computer, moving map, paper flight plan, and navigation charts.

12. Desired track
The concept of a great-circle route between two waypoints in the flight plan.

13. CDI/HSI/RMI set-up and sourcing
How to configure the navigation instruments to display guidance information generated by the RNAV computer(s).

14. CDI sensitivity
How all IFR GPS units offer three different sensitivities (en route = 5 NM, terminal = 1 NM, and approach = 0.3 NM). How to manually set the sensitivity. Setting sensitivity for departure. Vertical guidance sensitivity.

15. Alternate airports
Regulatory requirements for choosing alternate airports when GPS is used for IFR navigation.

C. DEPARTURE

1. Use of MFD for departure
How to use the MFD for engine monitoring during takeoff and for terrain awareness during departure.

2. VNAV climb to ensure climb gradient
How to use the VNAV feature of the RNAV computer to comply with required departure procedure climb gradients.

D. EN ROUTE

1. En route navigation concepts
Active waypoint, desired track, track, and bearing concepts.

2. Sequencing mode
En route behavior of the GPS computer when engaged in sequencing mode, including: waypoint alerting, turn anticipation, and waypoint sequencing.

3. Waypoint passage
Maintaining awareness of passing waypoints. Setting desired track to next active waypoint. The auto-slewing function.

4. Waypoint types
Difference between flyover and flyby waypoints.

5. Reporting course and/or speed
Determining present course or groundspeed when queried by ATC.

6. Direct to (waypoint in active flight plan)
Using the direct to function by selecting a waypoint that appears in the active flight plan.

7. Direct to (waypoint not in active flight plan)
Using the direct to function by entering a waypoint that does not appear in the active flight plan.

8. Direct to concepts
How the direct to operation builds a new leg from the present position of the aircraft to the entered waypoint. The importance of determining if the flight characteristics for this leg (e.g., weather, terrain, applicable regulations) are

different from the programmed flight plan. The future behavior of the GPS computer once the entered waypoint is reached.

9. Route editing
How to add and delete waypoints and procedures from the active flight plan.

10. Nearest airport or navigation facility
Using the nearest function of the GPS computer to find the nearest airport or navigation facility, along with any details about the facility stored in the navigation database.

11. Common Error: Loss of position awareness

12. Common Error: Loss of wind awareness

E. ARRIVAL
1. Approach armed mode awareness
Maintaining awareness when GPS computer switches to approach armed mode.

F. DESCENT
1. Elements of descent planning calculations
Initial altitude, target altitude, top-of-descent point, bottom-of-descent point, planned descent rate, planned descent speed, and winds. The wire-in-the-sky concept.

2. Manual descent calculations
Calculating a top-of-descent point given an initial cruising altitude, a crossing restriction, forecasted winds, and a planned descent rate and speed. Locating the calculated top-of-descent point on an aeronautical chart, pointing out all relevant minimum altitudes.

3. Calculating descents with the computer
Cross-checking manual descent calculations with those produced by the RNAV computer.

4. Energy management
Dissipation of potential and kinetic energy. Some navigation computers consider only potential energy, while other computers consider both. Pilot actions required with each type of computer.

5. Descent flying concepts
The importance of maintaining the planned descent path and speed. The effects of unanticipated winds. Controlling path with pitch, and speed with thrust and drag devices (when available).

6. Flying the descent
Maintaining the desired descent path and descent speed. Responding to path and speed excursions.

7. Determining arrival at the top-of-descent point

8. Early descents
Initiating a descent prior to the planned top-of-descent point. Recapturing the planned descent path at the planned descent speed when able.

9. Late descents
Initiating a descent after the planned top-of-descent point. Problem presented by late descents in terms of energy management. Proposes remedies for complying with crossing restrictions, and recognizes when crossing restrictions cannot safely be met.

10. Common Error: Winds not considered

G. RNAV APPROACH

1. RNAV approach concepts
Different types of RNAV approaches, including: LNAV, LNAV/VNAV, LPV, and GLS. Lateral and/or vertical guidance provided by each type of approach. The structure of an RNAV approach. Allowable equipment and equipment substitutions for each type of approach.

2. Determining approach minimums and missed approach point
Determining approach minimums and missed approach point based on approach selected, equipment available, and operational status.

3. Approach waypoints
Significance of special RNAV approach waypoints, including the initial approach fix, final approach fix, missed approach point, and missed approach hold point.

4. Approach active mode
The behavior of the RNAV computer when engaged in approach active mode, and the conditions required for approach active mode to become engaged.

5. Approach active mode awareness
Maintaining awareness when the RNAV computer switches from approach armed to approach active mode.

6. Flying the RNAV approach
Following an RNAV precision or non-precision approach procedure.

7. Loss or degradation of signal during approach
Responding to loss or degradation of signal before and after the final approach fix.

8. Approach not active
Responding to approach-not-active indications.

9. Selecting different procedures
Programming the RNAV computer to follow a different approach or transition.

10. Common Error: Approach active mode not checked

11. Common Error: Using wrong approach minimums.

H. INTERCEPT AND TRACK COURSE

1. Course intercepts
The steps required to intercept a course to the same or different active waypoint.

2. Nonsequencing mode
The behavior of the RNAV computer when engaged in the nonsequencing mode. The practical uses of the nonsequencing mode.

3. Advanced waypoint concept
How area navigation allows the pilot to determine bearing to a waypoint and home to a waypoint following any desired course.

4. Different inbound course, same active waypoint

How to engage the nonsequencing mode, set an inbound course to the same active waypoint, and review inputs for accuracy.

5. Different inbound course, different waypoint
How to set a new active waypoint, engage the nonsequencing mode, set an inbound course, and review inputs for accuracy.

6. No further input predictions
Predicting the future behavior of the aircraft during a course intercept operation given no further pilot inputs.

7. Reengaging sequencing mode
How to re-engage the sequencing mode once the course is intercepted.

8. Vectored departure procedure
How to use the course intercept techniques to accomplish a vectored departure procedure.

9. Vectored approach
How to use the course intercept techniques to accomplish a vectored approach.

10. Calculating intermediate waypoints
How to determine arrival at published waypoints by referencing other waypoints that appear in the RNAV route.

11. Activating a leg
How to activate different legs that appear in the RNAV flight plan.

12. Switching between modes
The behavior of the RNAV computer when switched from sequencing to nonsequencing modes, and vice versa.

13. Common error: Sequencing mode not reengaged

14. Common error: Mis-set inbound course

15. Common error: Reengaging sequencing mode too soon

16. Common error: Reengaging sequencing mode after FAF

I. VECTORS-TO-FINAL

1. Activating vectors to final
How to use the vectors-to-final feature of the RNAV computer.

2. How VTF works
What pilot actions are required to elicit the same behavior as the VTF function.

3. No further input predictions
Predicting the future behavior of the aircraft while using the VTF feature given no further pilot inputs.

4. Reverting out of VTF
Reselecting an approach without the VTF option, and resuming the approach.

J. ARCS

1. Arcs as leg types
How an arc is stored in the RNAV computer as a curvilinear leg with a constantly-changing desired track.

2. Loading an approach with an arc
How to load an RNAV approach that contains an arc.

3. Joining an arc at an IAF
Joining an arc at the initial approach fix.

4. Joining an arc at an arbitrary intercept point
Vectors to join an arc at an arbitrary point.

K. HOLDS

1. Entering a hold
Engaging the nonsequencing mode or recognizing automatic mode transition prior to reaching a hold waypoint.

2. Flying distance legs
Using the RNAV computer to fly a hold pattern with assigned distance legs.

3. Manually determining hold entry, WCA, and time

Importance of maintaining skills needed to determine hold entry and calculate wind correction angles and time for the outbound leg, without reference to the RNAV computer.

4. Crossing hold fix
Recognizing arrival at the hold fix.

5. No further input predictions
Predicting the future behavior of the aircraft during a hold given no further pilot inputs.

6. Exiting hold
Reengaging sequencing mode at appropriate time or recognizing automatic mode switch.

7. Eliminating a hold
How to remove an undesired hold from the programmed flight plan.

8. Common Error: Loss of wind awareness

9. Common Error: Attempt to fly hold as depicted on moving map

10. Common Error: Sequencing/nonsequencing mode mismanagement.

L. PROCEDURE TURNS

1. Initiating a procedure turn
Engaging the nonsequencing mode or recognizing automatic mode switch.

2. Complying with protected airspace restrictions
Use of the computer to ensure that procedure turns are accomplished within the boundaries of protected airspace.

3. No further input predictions
Predicting the future behavior of the aircraft during a procedure turn given no further pilot inputs.

4. Exiting procedure turn
Reengaging the sequencing mode or recognizing automatic mode switch.

5. Eliminating a procedure turn
How to remove an undesired procedure turn from the programmed flight plan.

6. Common Error: Nonsequencing mode mismanagement.

M. MISSED APPROACHES
1. Recognizing missed approach point
Determining arrival at the missed approach point. Maintaining awareness of proximity to missed approach point.

2. Initiating missed approach
Engaging the sequencing mode and accomplishing published or ATC-issued missed approach procedure.

3. Executing a missed hold procedure

4. Setting up next procedure in hold
Programming the RNAV computer for the next procedure or en route segment while flying a hold.

5. Initiating early missed approach
How to force the RNAV computer to begin a missed approach prior to reaching the missed approach point.

6. Complying with ATC-issued missed approach instructions
Programming an ATC-issued missed approach procedure, different from the published procedure.

7. Common Error: Delay in initial climb instructions

8. Common Error: Non-compliance with initial missed approach instructions

9. Common Error: Overrunning missed approach point

N. DUAL RNAV COMPUTER SKILLS

1. Flight plan cross-fill
Configuring two RNAV computers to cross-fill entries made into either computer.

2. Use of second RNAV computer for alternate flight planning

3. Using second RNAV computer to determine DME fixes and courses

II. RADIO NAVIGATION

1. Tuning and identifying a navigation facility

2. CDI/HSI/RMI set-up
Setting the CDI/HSI/RMI to display radio navigation indications and setting the desired course.

3. GPS as DME, ADF, or LOM
How to use GPS as a substitute for a DME, ADF, or LOM.

4. Load radio navigation approach in RNAV computer
How to use an RNAV computer as a backup reference when using radio navigation.

5. Common Error: Using map or GPS as primary

6. Common Error: Not using timer to identify MAP

7. Common Error: Not recognizing minimum altitudes for radio navigation facility reception.

8. Common Error: Loss of position awareness

4. Guidance Systems

I. AUTOPILOT

A. AUTOPILOT CONCEPTS
1. Functions performed by an autopilot
How an autopilot offers lateral and vertical guidance and control functions.

B. FLY HEADING
1. Setting the heading bug and engaging the heading function

2. No further input predictions
Predicting the future behavior of the aircraft when the heading function is used given no further pilot inputs.

3. Making turns greater than 180 degrees
How the autopilot automatically minimizes the size of turns.

4. Common Error: Turn greater than 180 degrees

C. FOLLOW ROUTE
1. Engaging the navigation function

2. Waypoint passage
Recognizing the passage of each RNAV waypoint, VOR station, or intersection. Adjust heading and course bugs as appropriate.

3. No further input predictions
Predicting the future behavior of the aircraft when the navigation function is used given no further pilot inputs.

4. GPSS function
The use of the GPS steering function and how it differs from other lateral guidance functions.

5. Common Error: Mixing up navigation and GPSS functions

D. MAINTAIN ALTITUDE

1. Engaging the altitude function at arbitrary altitudes

2. Barometric aiding
Some autopilots require input of local altimeter setting.

3. Altitude adjustments
Making small adjustments in altitude.

4. No further input predictions
Predicting the future behavior of the aircraft when the altitude function is engaged given no further pilot inputs.

5. Effect of updrafts and downdrafts
Effects of updrafts and downdrafts on airspeed. Stall awareness.

E. CLIMBS AND DESCENTS
1. The speed function
How the speed function works. Setting the target speed and engaging the speed function.

2. The vertical speed function
How the vertical speed function works. Setting the target vertical speed and engaging the vertical speed function.

3. Preventing stalls and over-speeds with the vertical speed function
How the vertical speed function aims to maintain a vertical speed, and will exceed the aircraft's normal range of operating speeds in order to maintain the target vertical speed. The need to adjust the target vertical speed with altitude.

4. No further input predictions
Predicting the future behavior of the aircraft when the speed or vertical speed function is used given no further pilot inputs.

5. Managing power settings during climbs and descents

F. CLIMBS AND DESCENTS TO ALTITUDE CAPTURES
1. Armed vs. engaged
The difference between an autopilot function that is armed vs. engaged. The concept of engagement conditions. The behavior of an autopilot function when it

automatically changes from armed to engaged when the engagement conditions are met.

2. Engaging vertical speed, arming altitude
Setting the vertical speed, engaging the vertical speed function, arming the altitude function, and reviewing inputs.

3. No further input predictions
Predicting the future behavior of the aircraft during a climb or descent to capture given no further pilot inputs.

4. Altitude awareness
Recognizing and acknowledging when the aircraft reaches one thousand feet prior to the target altitude.

5. Altitude alerter
Use of altitude alerter as a backup to pilot altitude awareness.

6. Altitude capture
Announcing when the autopilot has captured the target altitude, and acknowledging the change to armed and engaged functions. Behavior of autopilot during capture. Capture conditions.

7. Altitude capture with autopilot - pilot's responsibility
Capturing the target altitude is entirely the responsibility of the pilot-in-command, independent of whether or not the autopilot is used.

G. CAPTURE PRESENT ALTITUDE
1. Manually capture present altitude
How the autopilot can be used to capture the present altitude of the aircraft.

H. ASSIGNED HEADING TO INTERCEPT COURSE
1. Engaging heading, arming navigation
Setting the course to be captured, setting the heading bug, engaging the heading function, arming the navigation, approach, or GPSS function, and reviewing inputs.

2. No further input predictions

Predicting the future behavior of the aircraft during a course intercept operation given no further pilot inputs.

3. Course capture awareness
Recognizing when the autopilot has captured the course, and pointing out changes to armed and engaged functions.

4. Common Error: Heading function engaged but navigation function not armed

5. Common Error: Intercept angle too steep

I. STRAIGHT-IN RNAV APPROACH
1. Engage approach or GPSS function
Engaging the approach or GPSS function at the appropriate time during an approach.

2. Autopilot limitations for approaches
The limitations (stated in the pilot operating handbook and on the instrument approach plate) for using the autopilot during an instrument approach.

3. Step-down waypoints
Using the vertical speed and altitude functions to comply with altitude restrictions for each approach waypoint.

J. STRAIGHT-IN PRECISION APPROACH
1. Engaging the approach function

2. Glide slope armed
Recognizing the arming of glide slope function.

3. Glide slope captured
Recognizing glide slope capture and engagement of the glide slope function. Requirements for glide slope function engagement.

4. Forcing glide slope capture
How to manually engage the autopilot's glide slope function at any time during a precision approach.

K. MISSED APPROACH

1. Autopilot limitations
Limitations on the use of the autopilot (stated in pilot operating handbook and on instrument approach plate) for missed approach procedures.

L. HOLDS AND PROCEDURE TURNS

1. Outbound leg
Use of the heading function for outbound leg and turns.

2. Inbound leg
Arming the navigation or GPSS function for inbound leg and turns.

M. MISCELLANEOUS AUTOPILOT

1. Disconnecting the autopilot
All methods of disabling the autopilot. Rules for disconnecting the autopilot during approach operations.

2. Preflighting the autopilot
Manufacturer's approved procedures for testing the autopilot prior to flight.

3. How autopilot affects instrument scan
How the use of an autopilot affects the pilot's instrument scan and division of attention.

4. Effect of barometric changes on autopilot behavior

5. Autopilots in turbulence and icing
Manufacturer-approved procedures for using the autopilot in turbulence or icing conditions.

6. Autopilot limitations
Limitations on the use of the autopilot prescribed in the pilot operating handbook (POH) or aircraft flight manual (AFM). Requirement to engage lateral functions before vertical functions.

7. Control wheel steering (CWS)

8. Yaw dampers

9. The back-course function

10. Autopilot sourcing

Importance of remaining aware of which navigation/guidance source the autopilot is following.

II. FLIGHT DIRECTOR

A. FLIGHT DIRECTOR BASICS

1. Flight director functions

The functions performed by a flight director, and how the flight director works with other systems to perform its functions.

2. Flight director limitations

Limitations placed on flight director use as described in the pilot operating handbook.

3. Following flight director commands

How to use the flight director for any flight maneuver or procedure.

4. Maintaining awareness

How the flight director draws the pilot flying to the lowest level of awareness: the guidance commands generated by the autopilot. How, in addition to following the flight director commands, the pilot flying must remain aware of, and supervise, the navigation and guidance tasks that are being performed automatically.

5. Common Error: Blindly following indications

6. Common Error: Confusion about when autopilot is coupled

5. Cockpit Information Systems

I. MULTIFUNCTION DISPLAY

A. MFD BASICS

1. Multifunction display concepts

How multifunction displays present information from a variety of different avionics systems. Reversionary display modes. Failure indications.

B. MFD FUNCTIONS

1. Moving map

Using the moving map display and applicable regulations. Adjusting the map range and select map features. Avoiding over-reliance and maintaining lateral and vertical position awareness.

2. Electronic checklists

The use of normal, abnormal, and emergency electronic checklists. Applicable regulations for the acceptable uses of electronic checklists.

3. Electronic charts

The use of electronic charts and applicable regulations. The need for backup charts.

4. Limitations of multifunction displays

5. MFD failure

6. Common Error: Using MFD as primary navigation display.

II. TRAFFIC SYSTEMS

1. Traffic system basics

The functions performed by traffic systems such as TCAS and TIS, how the use of traffic systems affects the role of the pilot or crew, limitations of traffic systems, the kinds of alerts provided by traffic systems, and procedures for responding to traffic alerts.

2. Setting traffic system sensitivity
How to manually adjust the sensitivity of the traffic system.

3. Mapping display targets to out-the-window targets
Using the traffic display to expedite the visual acquisition of targets out the window.

4. Responding to traffic alerts
Making appropriate avoidance response to traffic alerts issued by either a traffic system or ATC.

5. Traffic awareness
Maintaining the same or higher level of overall awareness of surrounding traffic when a traffic system is used.

6. Common Error: Reporting traffic when not visually acquired

7. Common Error: Outside scan complacency, primary/secondary task inversion

III. COCKPIT WEATHER SYSTEMS

1. On-board sensors

2. Data-link systems

3. Displaying weather information
How to display weather information, provided by cockpit weather systems, on the multifunction display.

4. Interpreting weather data
How to properly interpret data presented by a cockpit weather system.

5. Weather avoidance
Tactical weather avoidance using weather data.

6. Risk assessment
The effect of more weather information on pilot risk estimations.

7. Limitations of weather data

8. Common Error: No weather briefing

IV. FUEL MANAGEMENT SYSTEMS

1. System basics
How fuel management systems work. The relationship between measured fuel holdings and burns correspond to those calculated by the fuel management system.

2. Initial fuel estimates
How to make accurate estimations of pre-departure fuel and enter estimate into computer. The importance of making an accurate initial estimation of fuel on board.

3. Determining fuel on board
Determining and cross-checking fuel on board using fuel gauges and fuel management computer.

4. Determining current endurance
Determining current endurance using hand calculations and computer.

5. Determining landing fuel
Predicting landing fuel using hand calculations and computer.

6. Alternate destination planning
Using the fuel management system to recognize the need for and carry out alternate destination planning.

7. Risk assessment
The effect of predictive fuel, range, and endurance information on pilot risk assessments.

V. TERRAIN AWARENESS AND AVOIDANCE SYSTEMS

1. System basics
Functions provided by terrain awareness and avoidance systems such as TAWS A, TAWS B, and EGPWS, including: excessive terrain closure rates, imminent contact alerts, negative climb rates, downward deviations from glide slopes, and voice callouts in landing configuration.

2. Determining safety of climbs, descents, and altitudes
Using terrain awareness and avoidance systems to verify that planned altitude and altitude changes maintain adequate terrain separation.

3. Responding to terrain alerts

4. Choosing terrain displays and configurations

5. Regulatory requirements
Part 135 regulatory requirements for TAWS A; Part 135 and Part 91 requirements for TAWS B.

6. Risk assessment
The effect of detailed terrain information on pilot risk assessment and decision making.

6. Emergency Operations

A. ENGINE FAILURE

1. Use of the nearest airport function of the area navigation computer

B. ELECTRICAL FAILURE

1. Partial and total failures of the electrical system

C. RUNAWAY AUTOPILOT/TRIM

1. Recovery from runaway autopilot/trim

D. INSTRUMENT SYSTEM FAILURES

1. Methods of dealing with instrument system failures. Using other multifunction display, partial panel, use backup or secondary instruments.

E. LOSS OF AREA AND/OR RADIO NAVIGATION CAPABILITY

1. Loss of navigation capability in radar environment

2. Loss of navigation capability in non-radar environment

Technically Advanced Aircraft Flying Handbook

Chapter Excerpts

Descent

Making the transition from cruise flight down to the beginning of an instrument approach procedure sometimes requires that you arrive at a given waypoint at an assigned altitude. When this requirement is prescribed by a standard terminal arrival route (STAR) or issued to you by ATC, it is referred to as a **crossing restriction**. Even when no crossing restriction is given and you are left to descend at your own discretion, you will usually want to choose your own waypoint and altitude that conveniently positions you to start your approach. In either case, the problem and its solution are the same.

Descending a technically advanced aircraft from a cruising altitude to a given waypoint and altitude not only requires planning, but also precise flying.

Elements of descent planning calculations

Figure 1 illustrates the basic descent planning problem. The problem begins with an aircraft flying at an assigned **cruising altitude**. The aircraft must descend to an **assigned altitude** and reach that assigned altitude at a designated **bottom-of-descent point**. Your next step is to choose a **descent rate** and a **descent speed**. The ultimate goal is to calculate a **top-of-descent point**: that point at which, if you begin your descent and maintain the planned descent rate and speed, you will reach the assigned altitude at the designated bottom-of-descent point.

In a conventional aircraft, you must rely on manual calculations to solve the descent planning problem. In a technically advanced aircraft, you have two descent planning methods available to you: (1) manual calculations, and (2) the vertical navigation features of your area navigation computer. Skillful pilots of technically advanced aircraft typically use both methods and cross check them against one another. Not only does this help reduce the possibility of error, but also ensures that the pilot remains proficient with both methods.

Manual descent calculations

The simplest technique for calculating the distance required to descent is one that has been used by airline pilots for many years. The table in Figure 2 lists a descent ratio for many combinations of planned descent speeds and descent rates. Figuring a descent is a simple matter of looking up the **descent ratio** for your chosen descent speed and rate, and multiplying the descent ratio by the number of thousands of feet in altitude that you must descend. For example, suppose you are asked to descend from 11,000 feet to meet a crossing restriction at 3,000 feet. Since you must obey a 200-knot speed restriction as you approach your destination airport, you choose a descent speed of 180 knots and a descent rate of 1,000 feet per minute. Referring to the table in Figure 2, you see that your planned descent speed and rate indicate a ratio of 3.0. This means that you will need 3 NM for every 1,000 feet you must descend. You have been asked to descend a total of 8,000 feet (11,000 – 3,000 feet). 3 NM times 8 equals 24 NM. That is, you will need a total of 24 NM to descend 8,000 feet, and must therefore begin your descent 24 NM away from your end-of-descent point.

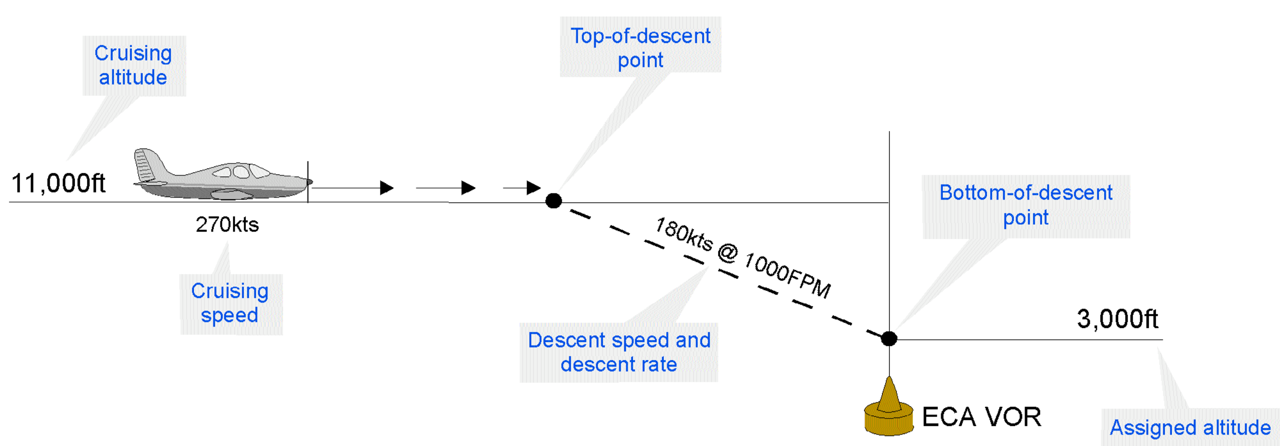

Figure 1. The descent planning problem.

DESCENT RATIO TABLE

A decent ratio table is provided for use in planning and executing descent procedures under known or approximate ground speed conditions and rates of decent. The ratio expresses the number of nautical miles needed to descend 1000 ft.

DESCENT GRADIENT RATE (ft./min)	GROUND SPEED (KNOTS) 90	100	120	140	160	180	200	220	240	260	280	300
500	3.0	3.3	3.7	4.6	5.3	6.0	6.7	7.3	8.0	8.7	9.3	10.0
600	2.5	2.8	3.1	3.9	4.4	5.0	5.6	6.1	6.7	7.2	7.8	8.3
700	2.1	2.4	2.6	3.3	3.8	4.3	4.8	5.3	5.7	6.2	6.7	7.1
800	1.9	2.1	2.3	2.9	3.3	3.8	4.2	4.6	5.0	5.4	5.8	6.3
900	1.7	1.9	2.0	2.6	3.0	3.3	3.7	4.1	4.4	4.8	5.2	5.6
1000	1.5	1.7	1.8	2.3	2.7	3.0	3.3	3.7	4.0	4.3	4.7	5.0
1100	1.4	1.5	1.7	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.5
1200	1.3	1.4	1.5	1.9	2.2	2.5	2.8	3.1	3.3	3.6	3.9	4.2
1300	1.2	1.3	1.4	1.8	2.1	2.3	2.6	2.8	3.1	3.3	3.6	3.8
1400	1.1	1.2	1.3	1.7	1.9	2.1	2.4	2.6	2.9	3.1	3.3	3.6
1500	1.0	1.1	1.2	1.6	1.8	2.0	2.2	2.4	2.7	2.9	3.1	3.3
1600	.9	1.0	1.1	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1
1700	.9	1.0	1.1	1.4	1.6	1.8	2.0	2.2	2.4	2.5	2.7	2.9
1800	.8	.9	1.0	1.3	1.5	1.7	1.9	2.0	2.2	2.4	2.6	2.8
1900	.8	.9	1.0	1.2	1.4	1.6	1.8	1.9	2.1	2.3	2.5	2.6
2000	.7	.8	.9	1.2	1.3	1.5	1.7	1.8	2.0	2.2	2.3	2.5

Figure 2. Descent ratio table.

A more complicated technique for figuring descents is to use the formula shown in Figure 3. Working through the formula for the ECA crossing restriction example, you can see that you will need 8 minutes to descend 8,000 feet at your planned descent rate of 1,000 feet/min. At your planned descent speed of 180 KTS, you will cover 3 NM per minute. Thus, in 8 minutes you will cover 24 NM. Once again, you find that you must start your descent 24 NM prior to ECA to meet the crossing restriction.

$$\frac{\text{Cruising Altitude (ft.) - Descent Altitude (ft.)}}{\text{Descent Rate (ft./min.)}} \text{ X } \frac{\text{Ground Speed (nm/hr.)}}{\text{60(min./hr.)}} = \text{nm required}$$

$$\frac{\text{11,000 ft. - 3,000 ft.}}{\text{1,000 ft./min.}} \text{ X } \frac{\text{180 nm/hr.}}{\text{60(min./hr.)}} = \frac{\text{8,000 ft.}}{\text{1,000 ft./min.}} \text{ X 3 nm/min.} = \text{8 X 3 nm} = \text{24 nm}$$

Figure 3. Manual descent calculations.

Coordinating your calculations with your aeronautical charts

Regardless of which method you use, it is always a good idea to locate the top-of-descent point you have chosen on your aeronautical chart. Figure 4 shows a chart that covers the area surrounding the ECA VOR. A top-of-descent point that is 24 NM prior to ECA is a point that lies 3 NM before PATYY intersection.

Alternate navigation planning

Using the aeronautical chart to locate your top-of-descent point has a second advantage. Recall that the regulations require you to have an alternate means of navigation on board. The aeronautical chart allows you check the minimum altitudes for VOR reception along your route of flight in the event that VOR navigation is required at any time. The airway that leads to the ECA VOR lists a minimum en route altitude (MEA) of 3,000 feet: the altitude to which you have been asked to descend.

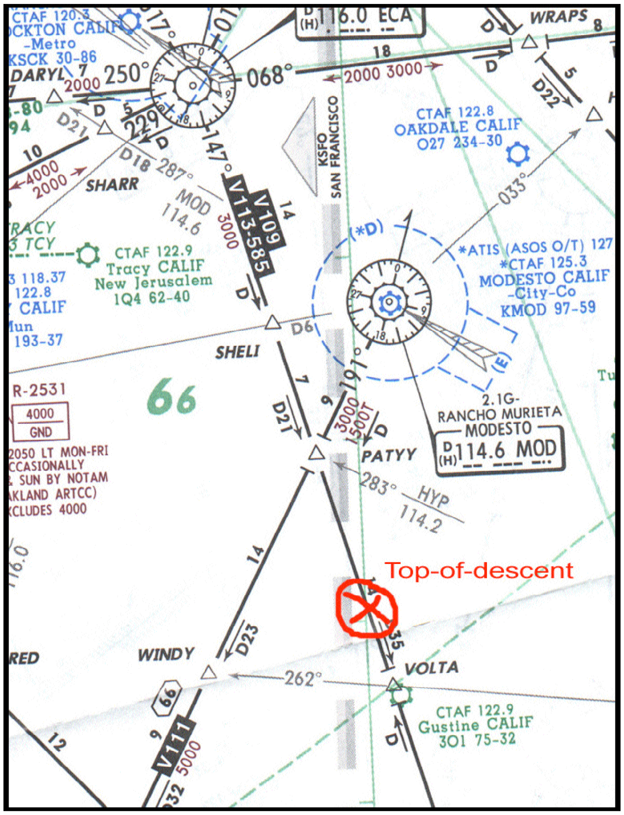

Figure 4. Finding the top-of-descent point on the en route chart.

Calculating descents with the computer

Building a descent with an area navigation computer follows the familiar process of entering the basics of the descent into the computer, letting the computer do the math, and then reviewing what the computer has produced.

Most area navigation computers offer a descent planning or vertical navigation (VNAV) page that allows you to enter the details of your descent. Figure 5 shows the VNAV page for one manufacturer's GPS computer. Note that there is an entry for each of the descent planning concepts we just discussed. Computers perform the calculations using the same formulae and data.

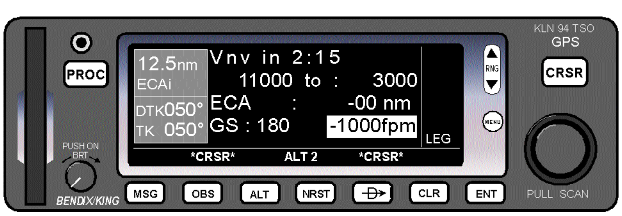

Figure 5. Vertical navigation page for one manufacturer's RNAV computer.

It is a good idea to cross check the results of your manual descent calculations with the results produced by the computer. Some more sophisticated flight management computers show you the top-of-descent point as it occurs in your flight plan. The T/D symbol on the map display in Figure 6 indicates the location of the top of descent point.

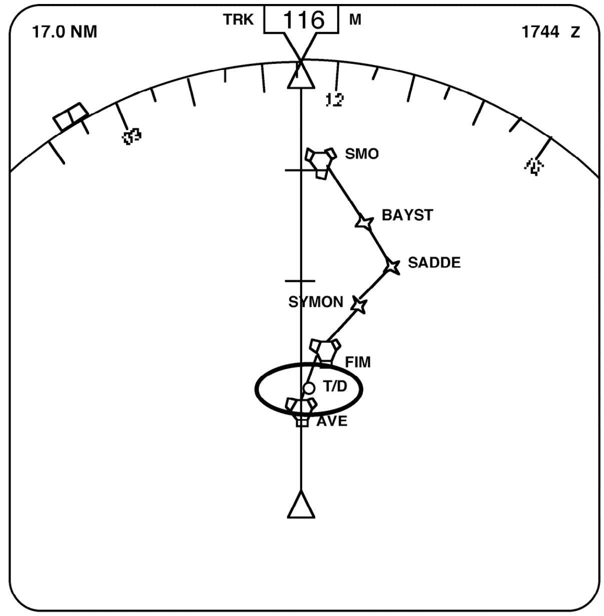

Figure 6. A moving map display that shows a planned top-of-descent point.

GPS receivers typically do not display a waypoint for the planned top-of-descent point. Even without an indication of the computer's planned top-of-descent point, you can still cross check your work by noting that the GPS computer should advise you to begin your descent approximately 3 NM before PATYY intersection (see Figure 7).

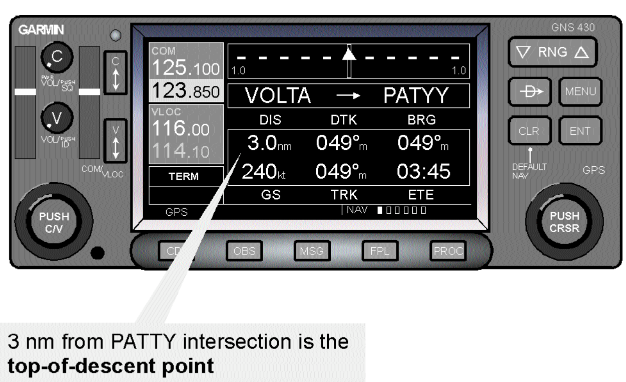

Figure 7. Estimating when the RNAV computer should advise you to begin your descent.

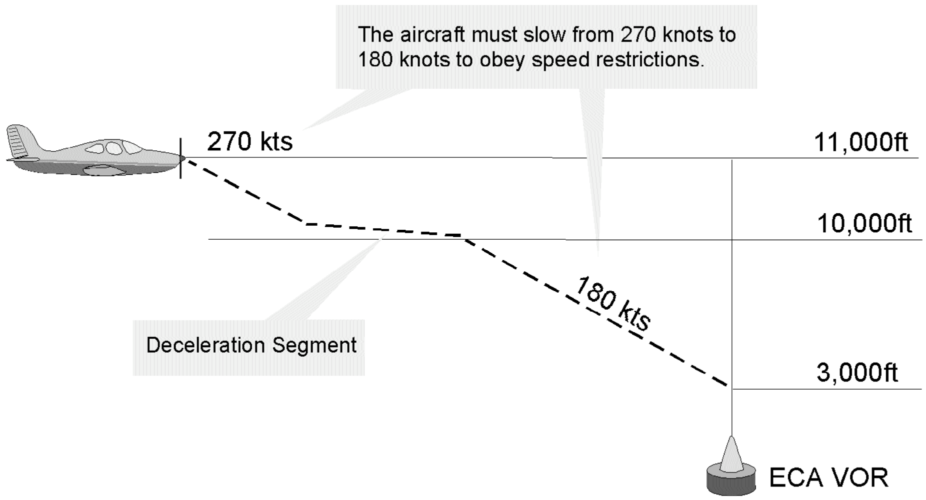

Figure 8. A deceleration segment planned in the middle of a descent.

Energy management

We have thus far focused on the problem of losing excess altitude. For example, in the scenario shown in Figure 1, you are faced with the problem of reducing your altitude from 11,000 feet to 3,000 feet. Most descent scenarios also present the problem of losing excess speed. In the scenario in Figure 1, a cruising speed of 270 KTS is inappropriate as you descend below 10,000 feet and even more so as you enter Class C airspace. Hence, your descent planning must also include provisions for losing excess airspeed to meet these speed restrictions.

Simple area navigation computers such as GPS receivers assume that you will slow the aircraft to the planned descent speed before reaching the planned top-of-descent point, and that your planned descent speed obeys all speed restrictions that may lie at your bottom-of-descent.

More sophisticated navigation computers are able to build in a **deceleration segment** that slows the aircraft from the planned descent speed to a one that obeys speed restrictions associated with various types of airspace. A deceleration segment is illustrated in Figure 8. Starting with a planned descent speed of 180 KTS, the computer knows to insert a deceleration to 180 KTS prior to reaching 10,000 feet.

In piston aircraft of modest performance, the problem of losing excess speed is one that seldom requires much forethought. Slowing from a cruising speed of 120 KTS to an approach speed of 100 KTS requires little planning, can be accomplished quickly at most any point during a descent, and is forgiving of most indiscretions. The transition to technically advanced aircraft requires us to take a closer look at these notions of excess altitude and excess speed.

Physicists refer to altitude as *potential energy* and speed as *kinetic energy*. Potential energy is the energy possessed by an aircraft because of its height above ground. Kinetic energy is the energy possessed by an aircraft because of its motion. Our aircraft cruising at 11,000 feet and 270 KTS possesses ample amounts of both types of energy. Our goal is to get the aircraft down to an altitude of 3,000 feet and a speed of 180 KTS. This goal requires that we get rid of considerable amounts of both types of energy.

It is a good idea to think about all altitude and speed changes as **energy management** problems. At any given time, your altitude and speed represent your **total energy**. When you must change altitude and/or speed, you must formulate a plan to manage your energy: to increase it or decrease it in gradual and elegant ways. These concepts will become important in surprise situations in which you must unexpectedly change altitude and/or speed. Unanticipated requests from ATC are the most common example.

Descent flying concepts

Probably the most important thing to realize about the descent you have just planned is that the descent is really a “wire-in-the-sky,” similar to the glide slope associated with an ILS procedure. If you start down at the planned top-of-descent point, fly a ground speed of 180 knots, and descend at 1,000 fpm, you will be flying on a fixed path as if someone had stretched a wire between your top-of-descent point and the bottom-of-descent point. If you maintain your 180-knot and 1,000-foot-per-minute descent, you will cross a point 18 NM from ECA at exactly 9,000 feet, a point 12 NM from ECA at 7,000 feet, and a point 6 NM from ECA at exactly 5,000 feet, as shown in Figure 9.

If you find yourself at any different altitude at any of these points, something went wrong and you can be guaranteed to not cross ECA at the required 3,000 feet unless you correct the situation.

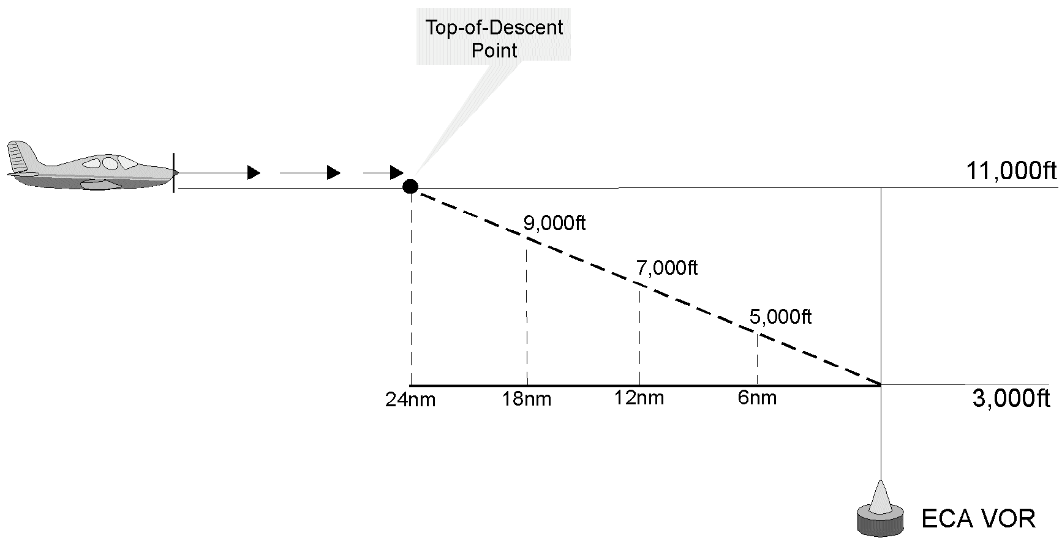

Figure 9. The planned descent path as a wire-in-the-sky.

Three things can cause you to drift off of a planned descent path:

1) not following the planned descent rate;
2) not following the planned descent speed;
3) unexpected winds.

Figure 10 shows the effect of each situation on the position of the aircraft with respect to the planned descent path.

Flying the descent

The real trick in flying a descent is to know your position relative to the wire-in-the-sky at all times. If you drift off the path, for whatever reason, you know you have to modify your descent speed and/or descent rate so that you can quickly rejoin the descent path.

Some area navigation computers show you your position with respect to the wire-in-the-sky.

Other computers do not give you a direct indication of your progress during your descent. In this case, you must follow the planned descent rate and speed as closely as possible and be mindful of your altitude and position as you approach the crossing restriction.

Determining arrival at the top-of-descent point

If air traffic control is able to accommodate you, the most ideal point to begin your descent is at the top-of-descent point that you have planned. All navigation computers provide some type of alert that tells you when you have arrived at the planned top of descent point, and that it is time to begin your descent at the speed and rate you have entered into the computer.

It is a good practice to announce your arrival at the top-of-descent point. Aside from keeping you in the loop, it will also help remind you to do other things like manage your power, complete descent checklists, etc.

In the case that air traffic control is unable to accommodate your request to commence your descent at your planned top-of-descent point, you are left with one of two scenarios.

Early descents

Beginning your descent before reaching the planned top-of-descent point means that you must set aside your descent planning and proceed without the benefit of vertical guidance offered by your navigation computer. If, during your descent, your navigation computer does not display your position with respect to the planned descent path, you must simply do the best you can to arrive at your crossing restriction at the assigned altitude.

If your navigation computer does display your position with respect to the planned descent path, you can generally recapture the planned descent path and resume flying with vertical guidance from the computer. The basic plan is to initiate a descent at a reasonable descent rate that is less than your planned descent rate. If you follow this initial descent rate, you will eventually intercept the planned descent path as shown in Figure 12.

Beginning your descent before reaching the planned top-of-descent point has the advantage of placing you in a low excess energy situation. You will now have more time and space to dissipate the energy stored in your excess altitude and excess speed. If at any point you find yourself too low or too slow (a low energy situation), you can fix the problem by simply adding power.

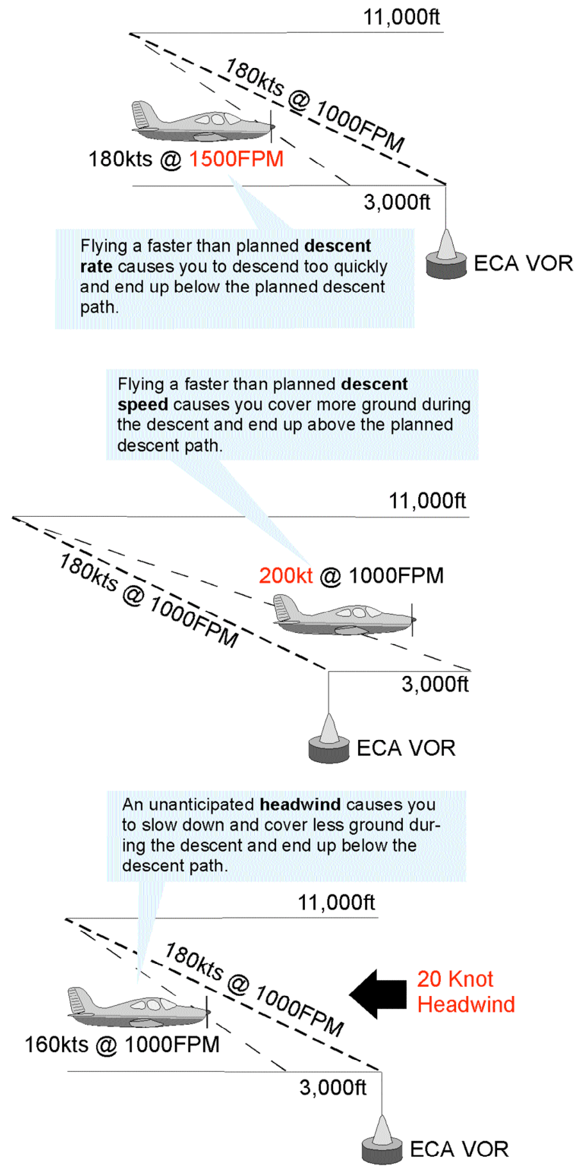

Figure 10. The effects of not following the planned descent rate or speed, and unanticipated winds.

Late descents

Beginning your descent beyond your planned top-of-descent point places you in a high excess energy situation. Flying past the planned top-of-descent point means that you will be left with the same amount of energy but have a shorter distance and time to lose that energy, as shown in Figure 13.

Looking at the point where you actually begin your descent, you are stuck with a greater amount of energy than you anticipated and must quickly formulate a plan to get rid of it. This can only be accomplished by adjusting your planned descent rate and/or speed.

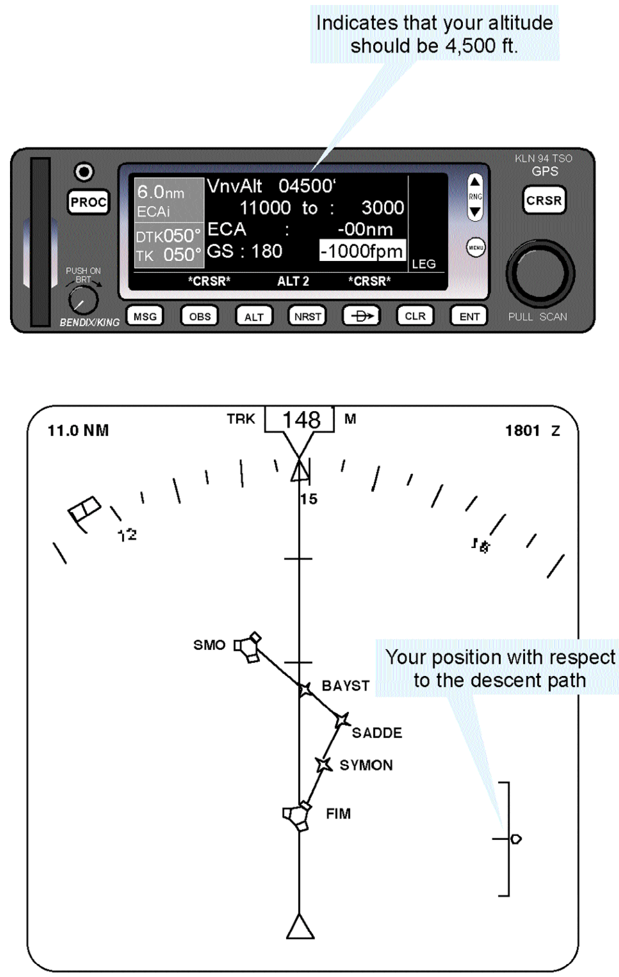

Figure 11. An RNAV receiver and a moving map display that show the aircraft's position with respect to the planned descent path during the descent.

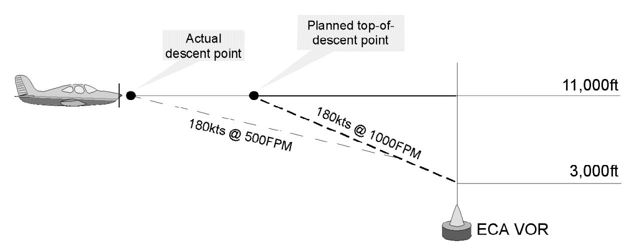

Figure 12. An early descent scenario.

Since the distance by which you over-run the planned top-of-descent point represents excess energy for which you have no plan, your true goal is to minimize that over-run distance. This is easily accomplished by slowing the aircraft as much as practical as soon as you learn of or suspect a late descent scenario: before or after the planned top-of-descent point. A slower speed means you will cover less distance in the same amount of time and thus be left with less excess energy.

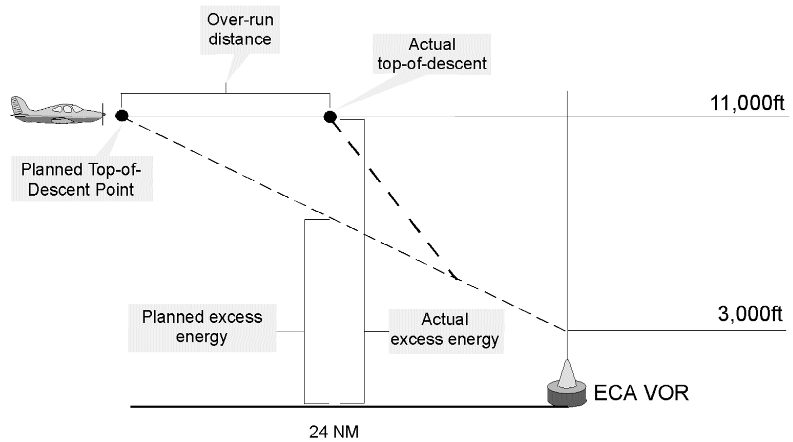

Figure 13. A late descent scenario.

Even following a quick and judicious speed reduction, late descent scenarios still leave you with excess energy. An increase in your planned descent rate means an increase in your descent speed, further complicating the problem. For this reason, late descents often require the use of drag devices to achieve higher descent rates at the same or slower speeds.

Common Errors

A common error made in flying a planned descent is to not consider the winds and their effect on ground speed. As illustrated in Figure 10 above, if you fail to take into account a 20-knot headwind, your ground speed will be slower than you planned, and you will reach your assigned altitude ahead of the target waypoint.

Intercept and track course

You have already seen how the sequencing mode of the GPS computer simplifies the problem of navigating between the waypoints that make up your flight route. When engaged in sequencing mode, the GPS computer automatically calculates the desired tracks between the waypoints. As you pass each waypoint, the GPS computer automatically sequences to the next waypoint in the flight route. As long as no changes to the flight route are necessary, you can simply follow the GPS computer's guidance without making any further inputs.

There are some situations in which it is desirable to turn off the automatic features offered by the GPS computer. For example, air traffic control will sometimes instruct you to fly to a waypoint following an inbound course that is different from the one calculated by the GPS computer. In this case, you need a way of overriding the GPS computer: that is, telling the GPS computer to follow a course of your choosing instead of the one that it has calculated.

The non-sequencing mode

In addition to the highly automated sequencing mode, every IFR-approved GPS computer also features a second mode of operation, called the **non-sequencing mode**. The non-sequencing mode differs from the sequencing mode in two important ways. First, the non-sequencing mode allows you to override the GPS-computed desired track to the active waypoint and input your own inbound course. Second, when the active waypoint is reached, the non-sequencing mode does not automatically sequence to the next waypoint in the flight route.

The use of the non-sequencing mode is illustrated using two common situations in which you will need to use the non-sequencing mode to choose your own inbound course to a waypoint.

Intercepting and tracking a course to the same active waypoint

Consider the situation in Figure 1 in which you are on your way to Sunol intersection and that the GPS computer has calculated a desired track of 070 degrees. The active waypoint (SUNOL) and the desired track of 070 degrees are shown on the GPS screen.

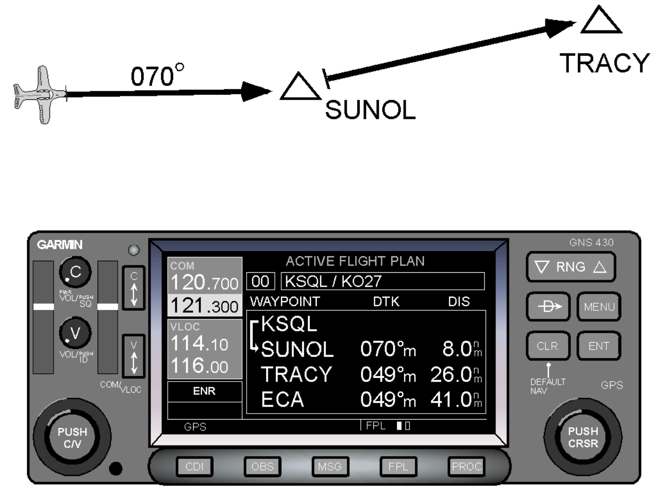

Figure 1. Enroute to the active waypoint in sequencing mode.

Suppose air traffic control intervenes and directs you to fly an assigned heading of 080 degrees to intercept and track the 009-degree course to Sunol intersection as shown in Figure 2.

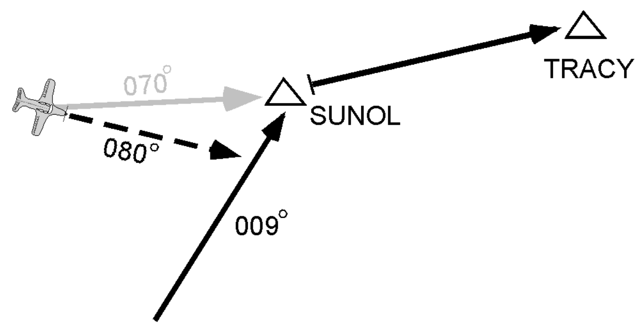

Figure 2. A vector to intercept a different course to the active waypoint.

The GPS computer is set to take you to Sunol intersection, but insists that you get to Sunol following an inbound course that is different from the one you have been instructed to follow. The non-sequencing mode allows you change the desired track of 070 degrees to 009 degrees.

Every GPS computer or integrated avionics system offers a simple way to switch to the non-sequencing mode (typically a button marked OBS) and an OBS or course knob to dial an inbound course to the active waypoint. Figure 3 illustrates the procedure for one particular GPS computer.

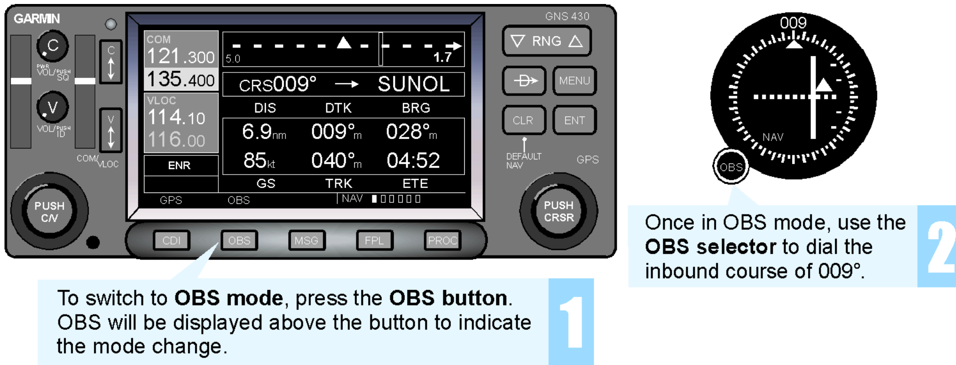

Figure 3. Engaging the non-sequencing mode and dialing the assigned intercept course.

Once you switch to the non-sequencing mode and dial the inbound course of 009 degrees, your navigation indicator will reflect your position with respect to the 009-degree course. The navigation indicator in Figure 3 shows that you are to the west of course. The assigned heading of 080 degrees seems to provide an acceptable intercept angle. After proceeding on the 080-degree heading, the needle will center as you reach the 009-degree radial.

Once you have reached the 009-degree course and the needle has centered, you can switch the GPS computer back into the sequencing mode prior to reaching Sunol intersection. You can then turn to track the 009-degree course to Sunol intersection. Once back in the sequencing mode, the GPS computer will automatically sequence you to the next waypoint in the route after you reach Sunol. You will then be flying in the simple "connect-the-waypoints" sequencing mode as before.

It is useful to review what you have done. The GPS computer had planned for you to fly to Sunol intersection following a 070-degree course. You agreed that you should go to Sunol intersection, but were not pleased with the inbound course. Therefore, you switched to the non-sequencing mode and dialed in a different course (009 degrees). You then intercepted and followed that course to Sunol.

Intercepting and tracking a course to a different active waypoint

Figure 4 illustrates a slightly more complicated request that is often made by air traffic control. In this situation, you have been instructed to fly a heading to intercept a course to a different waypoint. You now have two problems: you need to change not only the inbound course, but also the active waypoint.

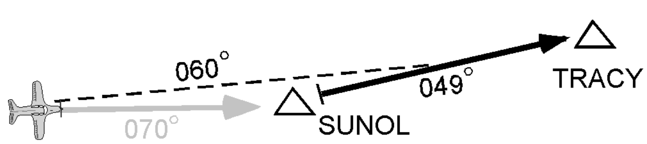

Figure 4. A vector to intercept an inbound course to a different waypoint.

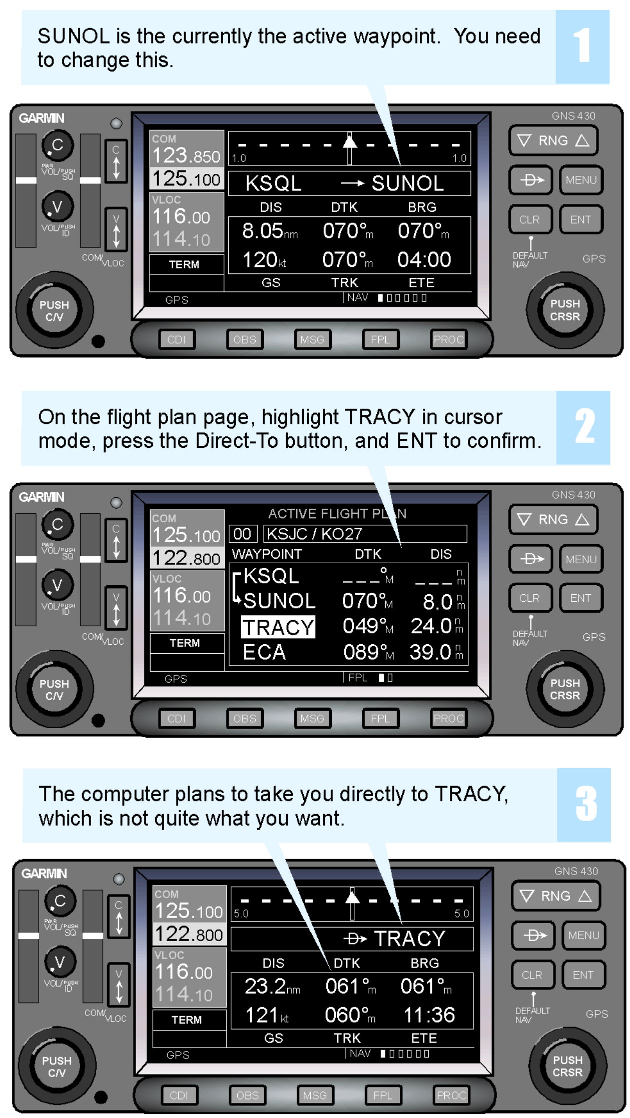

Figure 5. Using the direct-to function to set the active waypoint.

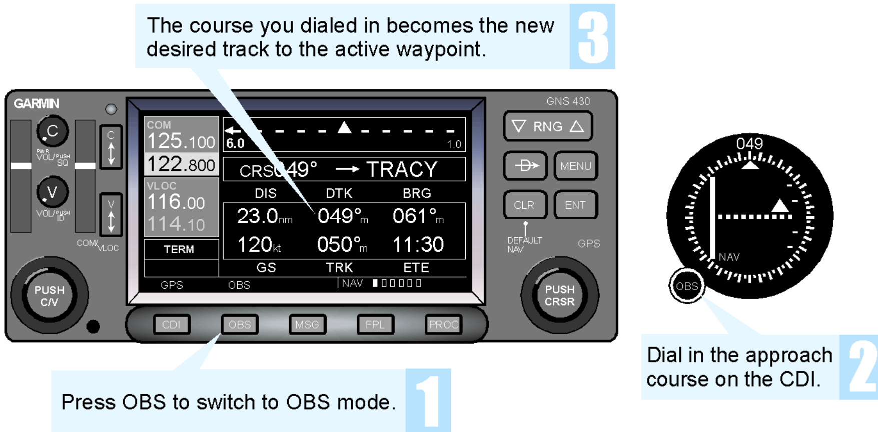

Figure 6. Using the non-sequencing (OBS) mode to dial the inbound course to the new active waypoint.

The first step is to change the active waypoint using the direct to function described earlier and illustrated in Figure 5.

But if you use the direct to function to make Tracy the active waypoint, the GPS computer will calculate a desired track that takes you from your present position to Tracy intersection.

The second step, illustrated in Figure 6, is to change the desired track to Tracy by setting the computer in the non-sequencing mode and dialing the inbound course.

You can now continue on your assigned heading until the needle centers, set the GPS computer back to the sequencing mode, and continue inbound on the assigned course to Tracy intersection.

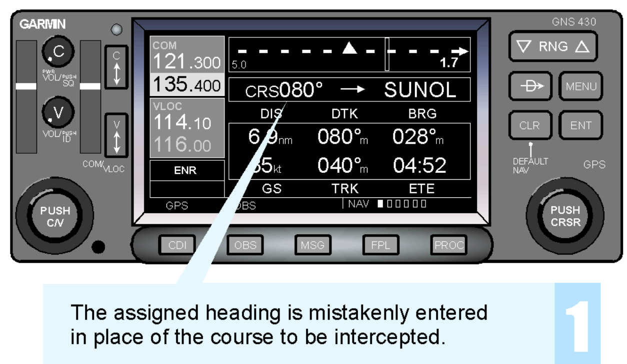

Figure 7. The common mistake of dialing the wrong course to the active waypoint.

Avoiding Common Errors

There are a number of common errors associated with the use of the non-sequencing mode to intercept and track courses. One error is to dial the wrong course to the active waypoint. Pilots will occasionally (and mistakenly) dial the heading that they have been assigned to fly to intercept the course. The outcome of this error is illustrated in Figure 7.

Another common error is to fail to realize that ATC has directed you to intercept a course to a different active waypoint. Figure 8 shows the outcome when the pilot neglects to set Tracy as the active waypoint in the previous example.

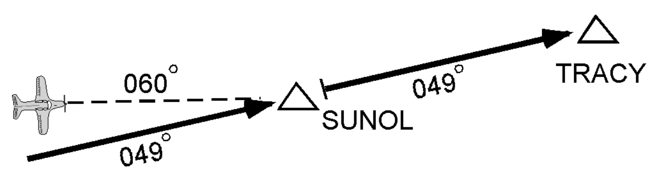

Figure 8. The common mistake of neglecting to set the correct active waypoint.

The GPS computer offers guidance along the correct course but to the wrong waypoint.

It is useful to call out the following two questions when working your way through a situation in which you are asked to depart and rejoin your programmed route using the non-sequencing mode:

Question #1: Where am I going?

Point to the active waypoint on the navigation page and make sure it shows the waypoint that you wish to fly toward.

Question #2: How am I getting there?
Point out the desired track to the active waypoint on the navigation page. If it isn't the one you want, push the OBS button and dial the course that you do want.

By far the most common error made with the non-sequencing mode is to forget to re-engage the sequencing mode once the course has been intercepted. The outcome of this error is that, once the active waypoint is reached, the GPS computer will not sequence to the next waypoint in the flight route.